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Date: 7/12/01 **Signature:** Gina Rust

Name: **Gina Rust**

SPECIFICATION

TO WHOM IT MAY CONCERN:

BE IT KNOWN, that We, Robert A. MacDonald, a resident of Hennepin County, Minnesota and a citizen of the United States and Robert J. Race, a resident of Dakota County, Minnesota and a citizen of the United States have invented certain new and useful improvements in:

MULTI-CHANNEL RETAINING WALL BLOCK AND SYSTEM

of which the following is a specification:

MULTI-CHANNEL RETAINING WALL BLOCK AND SYSTEM

Field of the Invention

This invention relates generally to retaining wall blocks and retaining walls constructed from such blocks. In particular, this invention relates to retaining wall blocks having channels, pin receiving apertures, and cores and a wall system made from such blocks that can be reinforced horizontally as well as vertically.

Background of the Invention

Retaining walls are used in various landscaping projects and are available in a wide variety of styles. Numerous methods and materials exist for the construction of retaining walls. Such methods include the use of natural stone, poured concrete, precast panels, masonry, and landscape timbers or railroad ties.

In recent years, segmental concrete retaining wall units, which are dry stacked (i.e., built without the use of mortar), have become widely accepted in the construction of retaining walls. An example of such a unit is described in U.S. Patent No. Re 34,314, which issued to Forsberg (Forsberg '314). Such retaining wall units have gained popularity because they are mass produced and, consequently, relatively inexpensive. They are structurally sound, easy and relatively inexpensive to install, and couple the durability of concrete with the attractiveness of various architectural finishes. The retaining wall system described in Forsberg '314 has been particularly successful because of its use of a block design that includes, among other design elements, a unique pinning system that interlocks and aligns the retaining wall units, thereby providing structural strength and allowing efficient installation. This system is advantageous in the construction of larger walls, when combined with the use of geogrids hooked over the pins, as described in U.S. Patent No. 4,914,876 to Forsberg ('876).

Another important feature of retaining wall blocks is the appearance of the block. The look of weathered natural stone is very appealing for retaining walls. There are several methods in the art to produce concrete retaining wall blocks having an appearance that to varying degrees mimics the look of natural stone. One well known method is to split the block during the manufacturing process so that the front face of the block has a fractured concrete surface that looks like a natural split rock. This is done by forming a slab in a mold and providing one or more grooves in the slab to function as one or more splitting planes. The slab is then split apart to form two or more blocks. Another method is wherein blocks are individually formed in a mold and the surfaces are textured by removal of the mold. Additional machine texturing processes can then be applied.

Creating a random, or ashlar, pattern in the face of a retaining wall is highly desirable. This gives the appearance of a mortared or dry-stacked natural stone wall, which is a traditional and well accepted look. Some current wall blocks are intended to create an ashlar pattern. However, the creation of a truly random appearance requires the production of multiple block shapes for use in a single retaining wall. This is inefficient from a production standpoint because this requires multiple molds and more kinds of blocks to inventory. If only one face of the block is intended to be the front face, then the block system will suffer a trade-off between having enough face sizes to create a random, natural appearance and the cost and inefficiency of using multiple molds and creating multiple inventory items.

Because of the natural variation in size of the stones used in stone retaining walls, the wall surface has variations in width from stone to stone. A system capable of duplicating this effect is described in U.S. Patent No. 6,149,352 (MacDonald), hereby incorporated herein by reference in its entirety. This system uses blocks of different widths and a connection system comprising a channel on each block and multiple pin receiving cavities to align the blocks. Thus this system can be used to produce a wall having random variations in face width and high structural integrity of the wall structure.

However, problems still remain in the field of retaining walls. Easy-to-use methods and systems that permit strengthening the wall, as well as tying in reinforcing geogrids into the earth behind a retaining wall, are continually sought.

It would be desirable to have a system of blocks for constructing a retaining wall that combines the ability to improve the reinforcement of the wall with the ease of installation of modern segmental retaining walls, while still providing for an attractive appearance of a natural stone wall. The block system should allow the construction of freestanding walls as well as curved walls and walls with 90 degree corners.

Summary of the Invention

This invention is a block system comprising multiple sizes and shapes of blocks with differently dimensioned, interchangeable front and back faces. The blocks can be used to construct an eye-pleasing, irregularly textured wall having a weathered, natural appearance. The texture of the wall is due to the variation in the size of the blocks, the weathered, natural appearance on the surfaces of the individual blocks, and the placement of the blocks in the wall. The shape of the blocks permits construction of stable walls having curved shapes as well as providing for walls having 90 degree corners.

The blocks are provided with cores, pin-receiving apertures, and multiple channels. Pins are used in the pin-receiving apertures to connect blocks in adjacent courses together. A further attachment system is formed by the use of reinforcing members within the channels on the blocks and/or through the cores of adjacent blocks.

In a first aspect, this invention is a wall having a front surface and a rear surface, the wall comprising at least a first lower course and a second upper course, each course comprising plurality of blocks; each block having an upper surface spaced apart from a substantially parallel lower surface, thereby defining a block thickness; opposed and substantially parallel first and second faces, the first face having an area greater than the second face; opposed and

non-parallel side surfaces, the first and second faces together with the upper, lower and side surfaces forming a block body; the lower surface having first and second channels substantially parallel to the first and second faces; and the blocks being positioned in the courses such that the front surface of the wall is formed from the first faces of a portion of the multiple wall blocks and the second faces of others of the multiple wall blocks.

The block may further comprise a third channel substantially parallel to the first and second faces. Each block may have the same thickness. The first and second channels each may open onto one of the side surfaces or onto each of the side surfaces. Each block may have a core and/or at least one pin receiving cavity extending through the block thickness. The pin receiving cavity may open onto the upper surface of the block or open into one of the at least two channels. One of the first and second channels may be adapted to receive a horizontal reinforcement member. The width of the blocks is defined by the first face of the blocks and the blocks may comprise blocks of three different block widths. The wall may further comprise horizontal reinforcing members adapted to fit within one of the first and second channels of the blocks. The blocks may further comprise at least one core extending the thickness of the first and the second blocks. The wall may further comprise vertically aligned blocks in the first lower course and the second upper course and vertical reinforcing members adapted to fit through the cores of vertically aligned blocks. The upper surface of each block may have pin receiving apertures substantially perpendicular to the upper and lower surfaces of the blocks. The first and second faces and at least one side surface may be textured in a manner resulting in the appearance of natural stone.

In a second aspect, this invention is a wall block for use in forming a wall from multiple wall blocks, the wall having a front surface and a rear surface, the block comprising an upper surface spaced apart from a substantially parallel lower surface, thereby defining a block thickness; opposed and substantially parallel first and second faces, the first face having an area greater than the second face; opposed and non-parallel side surfaces,

the first and second faces together with the upper, lower and side surfaces forming a block body; the lower surface having first and second channels substantially parallel to the first and second faces; and wherein the block body is configured for construction of a wall having a front surface of the wall formed of the first faces of a portion of the multiple wall blocks and the second faces of others of the multiple wall blocks.

In a third aspect, this invention is a method of constructing a wall, the wall having a front surface and a rear surface, the method comprising providing a plurality of blocks, each block having an upper surface spaced apart from a substantially parallel lower surface, thereby defining a block thickness; opposed and substantially parallel first and second faces, the first face having an area greater than the second face; opposed and non-parallel side surfaces, the first and second faces together with the upper, lower and side surfaces forming a block body; the lower surface having first and second channels substantially parallel to the first and second faces; and placing the blocks in a first lower course and a second upper course such that the front surface of the wall is formed from the first faces of a portion of the multiple wall blocks and the second faces of others of the multiple wall blocks.

In a fourth aspect, this invention is a wall system for constructing a reinforced retaining wall having at least a first lower course of blocks and a second upper course of blocks, the wall system comprising a plurality of blocks, each block having an upper surface spaced apart from a substantially parallel lower surface, thereby defining a block thickness; opposed and substantially parallel first and second faces, the first face having an area greater than the second face; opposed and non-parallel side surfaces, the first and second faces together with the upper, lower and side surfaces forming a block body; the lower surface having first and second channels substantially parallel to the first and second faces; the upper surface of the blocks having at least one pin receiving aperture; a pin sized to be contained within the pin receiving aperture of a block to extend above the upper surface of the block a predetermined distance; a geogrid; and a geogrid connector, the blocks being

configured such that they are capable of being positioned when constructing the wall so that the first channel of the lower surface of a block in the upper course receives a pin extending from the upper surface of a block of the lower course and the second channel of the lower surface of the block in the upper course receives the geogrid connector such that the geogrid is secured within the second channel by the geogrid connector. In a preferred embodiment, the geogrid connector comprises a channel portion having first and second sides defining a channel therebetween and an elongate bar configured to engage a section of the geogrid within the channel. The channel may open onto the lower surface of the block. The geogrid may comprise geosynthetic fabric.

In a fifth aspect, this invention is a wall having a front surface and a rear surface, the wall comprising at least a first lower course and a second upper course, the upper and lower courses comprising a plurality of first and second blocks; each block having an upper surface spaced apart from a substantially parallel lower surface, thereby defining a block thickness; each block having opposed and substantially parallel first and second faces, thereby defining a block length, the first face having an area greater than the area of the second face; the first blocks each having first and second converging side surfaces, the lower surface of the first blocks having at least two channels that open onto the first and second side surfaces, each channel parallel to the first and second faces; the second blocks each having opposed and non-parallel side surfaces, a first side surface being substantially perpendicular to the first face and a second side surface being substantially non-perpendicular to the first face, the lower surface of the second blocks each having at least two channels that open onto only the second side surface, each channel parallel to the first and second faces; the blocks being positioned in the courses such that the front surface of the wall is comprised of the first faces of a plurality of the first and second blocks and the second faces of a plurality of the first and second blocks.

The wall may further comprise a straight section and a corner section, wherein the straight section comprises a plurality of the first blocks, and the corner section comprises a plurality of the second blocks, oriented in such a

manner to form a 90 degree angle. The blocks may further have three channels. The at least two channels may be adapted to receive a horizontal reinforcement member. The first face of the blocks defines a block width and the first and/or second blocks may comprise blocks of three different block widths. The wall may include horizontal reinforcing members adapted to fit within one of the at least two channels of the first and second blocks. Each block in the wall may further have at least one core extending the thickness of the block. The wall may also comprise vertically aligned blocks in the first lower course and the second upper course and vertical reinforcing members adapted to fit through the cores of vertically aligned blocks. The blocks may also have pin receiving apertures substantially perpendicular to the upper and lower surfaces of the blocks. When the blocks have pin receiving apertures and the wall further comprises pins, each pin having a head portion and a body portion, the head portion is configured to be received within one of the at least two channels of the lower surface of the block in the second upper course of the wall and the body portion is configured to be received in the pin receiving aperture of the block in the first lower course of the wall. The first and second faces and at least one side surface may be textured in a manner resulting in the appearance of natural stone.

In a sixth aspect, this invention is a method of constructing a wall, the wall having a front surface and a rear surface, the method comprising providing a plurality of blocks, each block having an upper surface spaced apart from a substantially parallel lower surface, thereby defining a block thickness; each block having opposed and substantially parallel first and second faces, thereby defining a block length, the first face having an area greater than the area of the second face; the first blocks each having first and second converging side surfaces, the width of the blocks defined by the first face, the lower surface of the first blocks having at least two channels that open onto the first and second side surfaces, each channel parallel to the first and second faces; the first and second blocks each having opposed and non-parallel side surfaces, thereby defining a block width, one of the side surfaces being substantially

perpendicular to the first face, the lower surface of the second blocks each having at least two channels that open onto only one side surface, each channel parallel to the first and second faces; placing the blocks in at least a first lower course and a second upper course such that the front surface of the wall is comprised of the first faces of the plurality of the first and second blocks and the second faces of a plurality of the first and second blocks. The blocks may be provided with an attachment system allowing the blocks in the first lower course to be attached to the blocks in the second upper course. The method may also include placing a geogrid between the first lower course and the second upper course.

In a seventh aspect, this invention is a retaining wall having at least a first lower course of blocks and a second upper course of blocks, the wall comprising a plurality of blocks, each block having an upper surface spaced apart from a substantially parallel lower surface, thereby defining a block thickness; opposed and substantially parallel first and second faces, the first face having an area greater than the second face; opposed and non-parallel side surfaces, the first and second faces together with the upper, lower and side surfaces forming a block body; the lower surface having first and second channels substantially parallel to the first and second faces; the upper surface of the blocks having at least one pin receiving aperture; a pin having a body portion and a head portion, the body portion sized to be contained within the pin receiving aperture of a block and the head portion extending above the upper surface of the block a predetermined distance, such that the head portion is engaged in one of the first and second channels of the lower surface of the block in the second upper course, thus forming an attachment between the courses of blocks.

In an eighth aspect, this invention is a method for constructing a reinforced retaining wall system having at least a first lower course of blocks and a second upper course of blocks, the method comprising providing a plurality of blocks, each block having an upper surface spaced apart from a substantially parallel lower surface, thereby defining a block thickness;

opposed and substantially parallel first and second faces, the first face having an area greater than the second face; opposed and non-parallel side surfaces, the first and second faces together with the upper, lower and side surfaces forming a block body; the lower surface having first and second channels substantially parallel to the first and second faces; the upper surface of the blocks having at least one pin receiving aperture; placing a pin within the pin receiving aperture of a block, the pin extending above the upper surface of the block a predetermined distance; providing a geogrid and a geogrid connector; and positioning the blocks when constructing the wall so that the first channel of the lower surface of a block in the upper course receives a pin extending from the upper surface of a block of the lower course and the second channel of the lower surface of the block in the upper course receives the geogrid connector such that the geogrid is secured within the second channel by the geogrid connector.

In a ninth aspect, this invention is a wall block for use in forming a wall from a plurality of wall blocks, the wall having at least a first lower course of blocks and a second upper course of blocks, blocks in the upper course being connected to blocks in the lower course by pins extending from a top surface of blocks in the lower course and received by a pin receiving cavity formed in the bottom surface of blocks in the upper course, the wall block comprising an upper surface spaced apart from a substantially parallel lower surface, thereby defining a block thickness; opposed and substantially parallel first and second faces, the first face having an area greater than the second face; opposed and non-parallel side surfaces, the first and second faces together with the upper, lower and side surfaces forming a block body; the lower surface having first and second channels substantially parallel to the first and second faces; and the block body being configured such that when a wall is constructed from the blocks, the front surface of the wall is formed of the first faces of a portion of the multiple wall blocks and the second faces of others of the multiple wall blocks, the first channel functioning as the pin receiving cavity when the first face forms a portion of a front surface of the wall and the second channel

functioning as the pin receiving cavity when the second face forms a portion of a front surface of the wall.

In a tenth aspect, this invention is a wall having at least a first lower course of blocks and a second upper course of blocks, the wall comprising a plurality of wall blocks, the blocks in the upper course being connected to blocks in the lower course by pins extending from a top surface of blocks in the lower course and received by a pin receiving cavity formed in the bottom surface of blocks in the upper course; the wall block comprising an upper surface spaced apart from a substantially parallel lower surface, thereby defining a block thickness; opposed and substantially parallel first and second faces, the first face having an area greater than the second face; opposed and non-parallel side surfaces, the first and second faces together with the upper, lower and side surfaces forming a block body; the lower surface having first and second channels substantially parallel to the first and second faces; the front surface of the wall being formed of the first faces of a portion of the multiple wall blocks and the second faces of others of the multiple wall blocks, the first channel functioning as the pin receiving cavity when the first face forms a portion of a front surface of the wall and the second channel functioning as the pin receiving cavity when the second face forms a portion of a front surface of the wall.

In an eleventh aspect, this invention is a method of constructing a wall having at least a first lower course of blocks and a second upper course of blocks, comprising providing a wall block comprising an upper surface spaced apart from a substantially parallel lower surface, thereby defining a block thickness; a pin receiving aperture substantially perpendicular to the upper and lower surfaces; opposed and substantially parallel first and second faces, the first face having an area greater than the second face; opposed and non-parallel side surfaces, the first and second faces together with the upper, lower and side surfaces forming a block body; the lower surface having first and second channels substantially parallel to the first and second faces; placing a pin in the pin receiving aperture so that it extends from the top surface of the block in the

lower course; connecting blocks in the upper course to blocks in the lower course by the pin received by a pin receiving cavity on the bottom surface of blocks in the upper course, such that the front surface of the wall is formed of the first faces of a portion of the multiple wall blocks and the second faces of others of the multiple wall blocks, the first channel functioning as the pin receiving cavity when the first face forms a portion of a front surface of the wall and the second channel functioning as the pin receiving cavity when the second face forms a portion of a front surface of the wall.

Brief Description of the Drawings

FIGS. 1A and 1B illustrate perspective views of a first embodiment of the retaining wall blocks of this invention, with the lower surfaces facing up.

FIGS. 2A, 2B, and 2C illustrate bottom views of the first embodiment of the retaining wall blocks.

FIGS. 3A and 3B illustrate perspective views of a second embodiment of the retaining wall blocks of this invention, with the lower surfaces facing up.

FIGS. 4A, 4B, and 4C illustrate bottom views of the second embodiment of the retaining wall blocks.

FIG. 5A illustrates a bottom view of the block of FIG. 1A; FIG. 5B illustrates a side view of the block FIG. 5A; and FIG. 5C is a front view of the block shown in FIG. 1A.

FIGS. 6A and 6B illustrate, respectively, the bottom views of other versions of the first and second embodiments of the blocks of this invention.

FIG. 7 illustrates a perspective view of a block of FIG. 6A, with the lower surface facing up, and with reinforcing members in place.

FIG. 8 illustrates a section view of a portion of a retaining wall according to this invention.

FIG. 9 illustrates a section view of a portion of a retaining wall according to this invention.

FIG. 10 illustrates a section view of the retaining wall system of this invention.

FIG. 11A illustrates a perspective view of a geogrid channel connector; FIG. 11B illustrates a cross section view of the connector; and FIG. 11C illustrates a detailed view of the connector in place in a block channel.

FIG. 12 illustrates a perspective view of one course of the blocks in a serpentine arrangement.

FIG. 13 illustrates an exploded view of a reinforced wall formed from the blocks of this invention.

FIG. 14 illustrates a perspective view of the wall of FIG. 13.

FIG. 15 illustrates a perspective view of a wall formed from blocks of varying thicknesses.

Detailed Description of the Preferred Embodiments

In this application, "upper" and "lower" refer to the placement of the block in a retaining wall. The lower, or bottom, surface is placed such that it faces the ground. In a retaining wall, one row of blocks is laid down, forming a course. An upper course is formed on top of this lower course by positioning the lower surface of one block on the upper surface of another block.

This invention comprises blocks of differing shapes and sizes that are used together in the construction of a wall. The blocks are configured to be compatible with each other in the construction of a retaining wall, a parapet wall, or a free-standing wall. These blocks are provided in two different styles or embodiments, each embodiment of the block having different shapes and sizes. A first embodiment (e.g., shown in FIGS. 1A, 1B, 2A to 2C, 5, and 6A) having blocks of three sizes is used in the construction of the wall except for corner or end portions. Two sizes of the blocks are shown in perspective views in FIGS. 1A and 1B. The bottom views of three sizes of blocks are shown in FIGS. 2A to 2C. FIGS. 1A and 2A show the same block. FIGS. 1B and 2B show the same block. The smallest block is shown in bottom view in FIG. 2C.

The second embodiment is shown in FIGS. 3A, 3B, and 4A to 4C. Again, there are blocks of three sizes and these blocks are used most often in

constructing the ends or corners of a wall. FIGS. 3A and 4A show the same block and 3B and 4B show the same block. The smallest block is shown only in bottom view in Figure 4C.

Blocks 100a and 200a are similarly dimensioned, as are blocks 100b and 200b, and 100c and 200c. In this way, the blocks can be used interchangeably and where necessary in a wall. As is well understood in the art, the blocks can be made of any desired dimension. Blocks of three sizes for each embodiment are illustrated, though it is to be understood that many different sizes could be made and used to construct a wall.

Preferably, each block of either embodiment has at least two faces that are textured in a manner resulting in the appearance of natural stone. Three of the faces may be textured. The faces have varying sizes based on variations in width. The orientation of the faces may be reversed so that either the front or the back of the block may serve as an exposed face, to give the wall a pleasing random variation of the block sizes that creates the look of a natural stone wall.

The blocks are provided with pin receiving apertures or holes and multiple channels that together provide for a way to positively connect courses of blocks to each other in a retaining wall. The pin attachment system allows the individual blocks to be aligned with varying degrees of forward or rearward projection, to give the wall builder another means of introducing randomness to the appearance of the wall face. In addition, reinforcing members can be used vertically in the wall and can be used horizontally within the block channels, thus adding additional strength to the wall.

The blocks can be used to construct retaining walls, parapet walls, and free-standing walls. Such walls may be straight, curved (serpentine) or may have sharp corners (i.e., 90 degree angles). Preferably, there is a natural-appearing finish on all exposed sides of the wall. Reinforcing geogrid tie-backs or geosynthetic fabrics (referred to generally as geogrids and geotextiles) may be used with pins that fit in the pin receiving cavities or with a connector that fits in the groove of a block. The wall system is designed to be easy to

install, structurally sound, and to meet or exceed all ASTM, IBC, and AASHTO requirements for retaining wall structures.

Turning now to the Figures, various block embodiments are described. Many elements in various block embodiments are identical in shape, size, relative placement, and function, and therefore the numbers for these elements do not change. Elements that vary from one block embodiment to another are denoted by suffices "a", "b", "c", "d", and so forth, and may be referred to in a general way by a number without its suffix. In many of the figures, the block is shown with its bottom, or lower, surface facing upward. It should be noted that the block preferably is manufactured with the lower surface facing up, however, when it is used to construct a wall, the lower surface (having the channels) faces down.

FIGS. 1 and 2 illustrate three sizes of a first embodiment of the block of this invention. Perspective views of blocks 100a and 100b are shown in FIGS. 1A and 1B. Bottom views of blocks 100a, 100b, and 100c are shown in FIGS. 2A to 2C, respectively. The block comprises lower surface 104 opposed and substantially parallel to upper surface 102, and opposing and substantially parallel first and second (also referred to as front and back) faces 106 and 108, respectively. For the purposes of this description, front face 106 is shown facing the viewer in FIG. 1A, however, it is to be understood that front and back are interchangeable when the blocks are used in a wall. The block also comprises opposing and converging side surfaces 110 and 112 (i.e., imaginary lines coincident with side surfaces 110 and 112 will eventually converge at some distance away from the back of block 100a). The side surfaces are separated by the width of the block. The side surfaces join the front and back faces to form rounded corners 113. Block 100a is shown with lower surface 104 facing up and upper surface 102 facing down. The upper and lower surfaces are separated by the thickness of the block. Block 100a is provided with core 116a that extends through the thickness of the block. Bridge or divider 118a provides support at the center of the core, and can be removed if desired. The lower surface of each block is provided with at least two channels

extending the width of the block. In a preferred embodiment, there are three channels, shown as elements 122a, 124a, and 126a on block 100a, that extend the width of the block and in a direction substantially parallel to the front and back surfaces of the block. Channels 122a and 126a each have a depth and a profile sufficient to permit the use of pins having a shoulder or lip to be used in the pin-receiving apertures. Channel 124a is typically is more rounded than channels 122a and 126a, being configured to receive a reinforcing member, as described further below. Channels 122a, 124a, and 126a open onto both side surfaces 110a and 112a, and these openings are denoted by numbers 123a, 125a, and 127a.

Block 100b in FIG. 1B has the same elements as block 100a, but core 116b has no bridge or divider such as that in block 100a. It should be noted that, in a preferred embodiment, side surfaces 110b and 110c are the same dimension as side surface 110a in block 100a. Front face 106b is not as wide as 106a, and front face 106c is not as wide as 106b, as can be seen by comparing FIG. 2A to FIG. 2B. Block 100c also has fewer pin receiving cavities than blocks 100a or 100b. For each block, 100a, 100b, and 100c, preferably both the front and back faces are textured to have the appearance of natural stone.

Multiple pin receiving apertures or pin holes are provided in the block, and these preferably extend through the thickness of the block on either side of the core. The apertures are in a direction perpendicular to the upper and lower surfaces. For example, pin receiving apertures or holes 133a extend through the block and open in channels 122 and 126, respectively, and pin holes 137a are shown opening onto lower surface 104a of the block 100a, as shown in FIG. 2A. Pins are used in the apertures in the channels when it is desired to align blocks directly over one another and thus construct a vertical wall. Pins are used in the other apertures (i.e., such as 137a) so that blocks can be offset, and the wall can be provided with set back. This results in a non-vertical wall, as described further below.

Three sizes of a second embodiment of the block of this invention are illustrated in FIGS. 3 and 4. The elements of the second embodiment of the block are substantially similar to the elements of the first embodiment.

FIGS. 3A and 3B show a perspective view of second block 200a and 200b, respectively, and corresponding bottom views are shown in FIGS. 4A and 4B. A substantially similar, but smaller, block 200c is illustrated in FIG. 4C. The elements of block 200a will now be described. Upper surface (facing down in the figure) 202a is opposed to and substantially parallel to lower surface 204a. Surface 202a is separated from surface 204a by the thickness of the block. First and second opposed faces 206a and 208a (also referred to as front and back faces, respectively) are substantially parallel. First face 206a has a greater surface area than second face 208a. First face 206a and second face 208a are joined by and orthogonal to first side surface 212a. That is, the angle formed by an imaginary line coincident with first face 206a and an imaginary line coincident with first side surface 212a is 90 degrees, and forms rounded corners 215a. First face 206a and second face 208a also are joined to second side surface 210a, thus forming rounded corners 213a. Side surfaces 210a and 212a are opposed and are non-parallel. Similarly, the angle formed between second face 208a and first side surface 212a is 90 degrees. The angles formed between either of the first and second faces and side surface 210a are non-orthogonal.

Block 200a is provided with through-passage or core 216a. Within core 216a is bridge or divider 218a. Blocks 200b and 200c are provided with cores 216b and 216c, respectively.

The lower surface of each block is provided with at least two channels extending the width of the block. In a preferred embodiment, blocks 200a, 200b, and 200c each have three channels. Lower surface 204a is provided with channels 222a, 224a, and 226a that are substantially parallel to the first and second (front and back) surfaces 206a and 208a and extend the width of the block. Channels 222a and 226a each have a depth and a profile sufficient to permit the use of pins having a shoulder or lip to be used in the pin-receiving

apertures. Channel 224a is typically is more rounded than channels 222a and 226a, being configured to receive a reinforcing member, as described further below. Channels 222a, 224a, and 226a extend to one side surface only and open onto the side surface 210a forming openings 223a, 225a, and 227a, respectively.

Channels 222a, 224a, and 226a extend to one side surface only because blocks 200a to 200c are primarily used for the ends or the corners of retaining walls, where the appearance of the block sides are important. That is, side surfaces 212a, 212b, and/or 212c would face the observer at a corner or end of a wall. It is undesirable to have the channels opening onto an exposed side surface. As one of skill in the art knows, however, the blocks could be used anywhere desired in a wall during its construction, simply by altering the block to open a channel to both sides of the block.

The blocks are provided with multiple pin receiving apertures that are in a direction perpendicular to the upper and lower surfaces and preferably extend through the thickness of the block. The figures illustrate blocks having eight or fewer apertures. The channels on either side of the core(s) are provided with pin receiving apertures and there are apertures disposed about either side of the core. Pin receiving apertures 233a and 235a extend through the block into channels 222a and 226a, as shown in FIG. 4, and apertures 237a are shown opening onto lower surface 204a of block 200a in FIG. 3A. The apertures are configured similarly to the apertures of blocks 100a to 100c.

As can be seen in FIGS. 3B and 4, block 200b is smaller than block 200a. Block 200c is smaller still, and has fewer pin receiving cavities than blocks 200a or 200b. This is because such cavities are sufficient to hold the smaller block in place in a wall.

The blocks of either embodiment are made of a rugged, weather resistant material, preferably (and typically) zero-slump molded concrete. Other suitable materials include wet cast concrete, plastic, reinforced fibers, wood, metal and stone. Blocks of this invention are typically manufactured of concrete and cast in a masonry block machine. The sides of the blocks may be

tapered. That is, for example, the surface area of the bottom of the block may be larger than the surface area of the top of the block. Tapering is typically due to the manufacturing processes, because it may be easier to remove a block with tapered sides from its mold.

Block 100a is again illustrated in FIG. 5A, and a side view of block 100a is shown in FIG. 5B. The core and four pin receiving apertures are shown in FIG. 5B. FIG. 5C shows the block from the first (i.e., front) face, and the core is shown in outline. For simplicity, only one set of pin receiving apertures is shown in FIG. 5C. It again should be noted that, a preferred manufacturing process is to form the blocks with the lower face upward so that the grooves can be formed easily. Thus the core may taper from the lower surface to the upper surface because tapering is done for manufacturing ease. Thus the core is wider at the top surface of the block than at the lower surface of the block

The block's dimensions are selected not only to produce a pleasing shape for the retaining wall, but also to permit ease of handling and installation. In addition, the dimensions of the channels and the pin receiving cavities are selected as desired. Typically blocks having one thickness and one length are used to construct a retaining wall. However, it may be desirable to use various thicknesses of blocks in a single course of a wall to create a random appearance. For the blocks illustrated in the figures, the length of the blocks (i.e., defined as the distance from the first face to the second face (i.e., front to back)) is about 11 inches (28 cm) and the thickness or height of the blocks ranges from about 3 inches (15.2 cm) to about 8 inches (20.3 cm). For example, a desirable thickness for the blocks is about 4 inches (10.2 cm). The first, or front (longer) face of blocks 100a and 200a is about 18 inches (45.7 cm) wide, and the back is about 14 inches (35.6 cm) wide. The front face of blocks 100b and 200b is about 12 inches (30.4 cm) wide, and the front face of blocks 100c and 200c is about 6 inches (15.2 cm) wide.

Providing a large core (i.e., large relative to the overall block size) is preferred because it results in a reduced weight for the block, thus permitting easier handing during installation of a retaining wall. However, the cores may

have any desired dimension. For example, core 116a of block 100a are 10.0 inches long and 5.75 inches wide (25 cm by 14.6 cm). The smallest core, such as that shown for block 100c, is about 4 inches long and 3 inches wide (10.2 cm by 7.6 cm).

FIGS. 6A and 6B illustrate further variations of the first and second embodiments, respectively. Blocks 300a and 400a should be compared to blocks 100a and 200a. These blocks differ in that they lack the bridge or divider such as 118a and 218a of blocks 100a and 200a, respectively. The other elements are substantially similar as described above and are numbered accordingly.

FIG. 7 illustrates block 300a of FIG. 6A with vertical and horizontal reinforcing members. The block is shown with its bottom or lower face up to show clearly the placement of reinforcing members. Vertical reinforcement rod 10 is shown through the core and horizontal reinforcement rod 20 is shown lying in channel 324a. Grout may be used in the channel to add further reinforcement. Suitable reinforcing rods include threaded steel (galvanized) post-tension rods, steel reinforcing bars (also referred to as "rebar", which may be natural and/or galvanized), fiberglass rods, and other reinforcing members that are suited for reinforcement in concrete/masonry.

Various walls are illustrated in cross section in FIGS. 8, 9, and 10. With this block system, various sizes of blocks can be aligned directly over one another, thus aligning the cores. This permits the wall to be reinforced vertically, and yet, because of the different sizes of the blocks, a random, natural appearance can still be obtained for the wall. Various design members can be used, including guardrail/handrail that can be anchored into the cores of the blocks with cement grout in a vertical wall, such as that shown in FIG. 10. The present system of blocks, pins, and horizontal reinforcement 20 in the channels is shown in FIG. 8. Retaining pins 30 preferably are provided with a lip, shoulder, or head portion 31 that prevents the pins from slipping through a pin-receiving aperture. A pin is placed into a pin receiving cavity (e.g., 135) in

a block on a lower course and is aligned so that the head portion 31 fits within a channel (e.g., 122 or 126) on the lower surface of a block above.

FIG. 9 is a side view of another type of retaining wall, in which the blocks of an upper course are set back from the blocks of a lower course, resulting in a wall that is set back or angled from vertical. In this set back, or staggered arrangement, pins are placed in apertures (e.g., 137) and the head of the pin fits in a channel (e.g., 122 or 126) of the block above the blocks. In addition, vertical reinforcing member 10 runs through the cores of the blocks and horizontal reinforcing members 20 run through the channels of the blocks. Both vertical and horizontal reinforcing members may be held in place and reinforced further by grout.

Cap, coping, or finish, layer 40 is installed at the top of the wall. The cap layer may comprise blocks, cut stone, or precast concrete pieces. Also, concrete can be cast in place for the finish layer. In any event, the cap layer may have any desired surface finish on its top and sides. Its thickness and appearance are matters of design choice. Typically the cap layer has no apertures that pass through its thickness. This layer may be affixed to the underlying course by means of adhesive (i.e., mortar or epoxy), pins, or other suitable means known to those of skill in the art.

FIGS. 8 and 9 also illustrate the use of a reinforcing material, or geogrid, which is generally a flat sheet of material arranged as a grid. It is contemplated that this reinforcing material is a relatively high strength geogrid, such as steel, or high strength polymeric material (e.g., polyester, polyaramid, polypropylene), or high density polyethylene (HDPE), though other types of geogrid or geotextiles may be suitable. Reinforcing material 60 may be installed and held in place by both the blocks and retaining pins 30 to create a mechanically stabilized earth retaining wall. Alternatively, various types of geogrid connectors, as known in the art, may be used in place of or in addition to the pins to hold the geogrid in place. The use of geogrids is known in the art and is described, for example, in U.S. Patent No. Re. 34,314 (Forsberg), hereby incorporated herein by reference. After placement of a course of blocks to the

desired height, the geogrid is placed so that the pins in the block penetrate the apertures of the geogrid. The reinforcing material is then laid back into the area behind the wall and put under tension by pulling back the reinforcing material. Backfill is placed and compacted over the reinforcing material, and the construction sequence continues as described above until another layer of reinforcing material is called for in the planned design. The use of a vertical reinforcing member also contributes to the resistance of pull out of the geogrid from the wall blocks.

FIG. 10 shows a cross section of a near-vertical or parapet wall, having capping layer 40, vertical reinforcing member 10, horizontal-reinforcing members 20 within the block channels, and geosynthetic reinforcement 70 held into place by connector 50 and tied into the earth behind the wall. When a railing is desired at the top of such a wall, railing support element 19 is fitted into a core of the blocks in the top course of blocks. Sidewalk or walkway S lies over the earth behind the wall. Connector 50, described further below, fits into a channel nearest the rear surface of the block, and geogrid extends from there into the earth behind the wall.

An optional reinforcing system is shown for vertical reinforcement. That is, vertical reinforcing member 10 has a threaded section so that it can be held in place by washer 15 on compression plate 17 on the topmost course of blocks. Pins 30 are placed in the pin-receiving apertures of the blocks. Heads 31 of retaining pins 30 fit within a channel (122 or 126) of a block lying on top of the pin. Pins 30 function to align the blocks as well as to hold blocks in adjacent courses together.

To construct the wall, a trench first is dug and concrete footing layer BB is placed in the trench. The first course of blocks is laid on top of footing BB. Both the footing layer and the first course of blocks are installed below grade. A compacted free-draining granular leveling pad can be used in place of footing BB. The footing or leveling pad creates a level and somewhat flexible wall support base and eliminates the need to trench to a depth that would resist frost. That is, the footing can move as the ground freezes. Optional filter

fabric FF is placed at the back surface of the wall. Filter fabric prevents the flow of fine silt or sand through the face of the wall but permits the flow of water, as is known to one of skill in the art.

Reinforcing member 10 extends vertically through the cores of the blocks and extends horizontally into the footing. Geosynthetic reinforcement or geotextile 70 is installed between the second and third course of blocks and held in place by a connector adapted to fit into a channel of the block, as described further below. The desired number of courses of blocks are added. The wall is finished, or capped, with cap layer 40.

Geosynthetic reinforcement 70 is a relatively flexible geogrid that, for example, comprises a rectilinear polymer construction characterized by large (e.g., 1 inch (25 cm) or greater) openings. In a typical open structure geogrids, polymeric strands are woven or "welded" (by means of adhesives and/or heat) together in a grid. Polymers used for making relatively flexible geogrids include polyester fibers. The polyester typically is coated with a polyvinyl chloride (PVC) or a latex topcoat. The coating may contain carbon black for ultraviolet (UV) stabilization. Some open structure geogrids comprise polyester yarn for the warp fibers and polypropylene as the fill fibers. Geosynthetic reinforcement 70 may also comprise geosynthetic fabric, i.e., woven constructions without large openings. These fabrics typically comprise polymers and are referred to as geofabrics.

FIG. 11A shows a perspective view of connector 50. Connector 50 is described in co-pending, commonly assigned U.S. patent application S. N. __________ filed on even date herewith, entitled "Grooved Retaining Wall Block and System", hereby incorporated herein by reference. Connector 50 includes channel portion 52 having first and second sides defining channel 54 therebetween and elongate bar 56 configured to engage a section of the geogrid within the channel. Connector 50 is sized to be accommodated within the groove of a block when the geogrid is engaged in the channel. A cross sectional view of connector 50 is shown in FIG. 11B, and FIG. 11C illustrates geosynthetic reinforcement 70 held in a channel (e.g., channel 226a of block

200a) by connector 50. FIG. 11C shows that the channel of the connector opens onto the lower surface of the block. The connector could also be oriented so that one of the surfaces of the channel connector faces the lower surface of the block.

Connector 50 comprises rigid polymeric material such as polyvinyl chloride or polyethylene copolymer and may be formed by extruding a suitable material into the desired shape. It also may comprise fiberglass. Connector 50 includes channel connector 52 having channel 54 which is configured to receive geosynthetic material. An end of the geofabric is laid into the channel and held in place by connector bar 56.

The connector illustrated in these figures is about 1 inch (2.5 cm) high and about 5/8 inch (1.6 cm) wide though any desired dimensions can be used for this connector. The length of the connector also may be any desired length, though for this wall the connector preferably is a length sufficient to accommodate the width of the geofabric.

FIG. 12 illustrates one course of blocks laid in a serpentine pattern. The surface having channels is facing downward. Blocks 100a, 100b, 100c are distributed throughout the course, and block 200b at the left side of the course of blocks. In this way, the left side has a finished appearance, since channels do not open onto the left side. This figure also illustrates that both first and second surfaces of the block form the face of a wall.

FIGS. 13 and 14 show an unfinished reinforced freestanding or retaining wall and FIG. 13 illustrates the exploded view of this wall. Wall 90 is constructed with the blocks of this invention and reinforced both vertically with vertical reinforcement members 10 in place through the cores of stacked blocks. Wall 90 is also reinforced horizontally by horizontal reinforcing members 20 that are laid in the center channel (e.g., 124) and extend the length of the wall. Footing BB also is shown in the figures, and vertical reinforcing members 10 can be seen extending into footing BB in FIG. 13. For the sake of simplicity, no pin receiving apertures are shown.

FIGS. 13 and 14 show wall 90 without end blocks (such as 200a, 200b,

and 200c) that would form a right angle at the end of the wall. The right side of the wall illustrates the appearance and position of the blocks and the channels therein. Each block is the same in length (i.e., distance from first to second face, or front to back) but different in width (i.e. distance from first to second side). Three blocks (e.g., 300a, 100b, and 100c) and capping layer 40 are shown. Either a reinforced retaining wall or parapet wall can be constructed with various sizes of blocks of this invention.

FIG. 15 illustrates wall 94 with the blocks of this invention having various thicknesses. The use of various thicknesses as well as different widths of blocks results in a pleasant random appearance (ashlar pattern) for the wall.

Although particular embodiments have been disclosed herein in detail, this has been done for purposes of illustration only, and is not intended to be limiting with respect to the scope of the claims. In particular, it is contemplated that various substitutions, alterations, and modifications may be made to the invention without departing from the spirit and scope of the invention as defined by the claims. For instance, the choice of materials or variations in the shape or angles at which some of the surfaces intersect are believed to be a matter of routine for a person of ordinary skill in the art with knowledge of the embodiments disclosed herein.